



GISTEMP Analysis of Global Surface Temperatures

GISTEMP Team: Reto Ruedy, Makiko Sato, Michael Hendrickson, Ken Lo, Nathan Lenssen, Gavin Schmidt



GISTEMP Land-Ocean Temperature Index (L-OTI)

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Continuation of analysis started in 1981

(Hansen and Lebedeff, 1987; Hansen et al; 1981; 1999; 2001; 2010; [Lenssen et al, 2019](#))

Input data sources (all publicly available):

Stations: [GHCNv4](#) (homogenized); [ERSST v5](#) Extrapolation using 1200km radius of influence

Correction for urban/rural differences

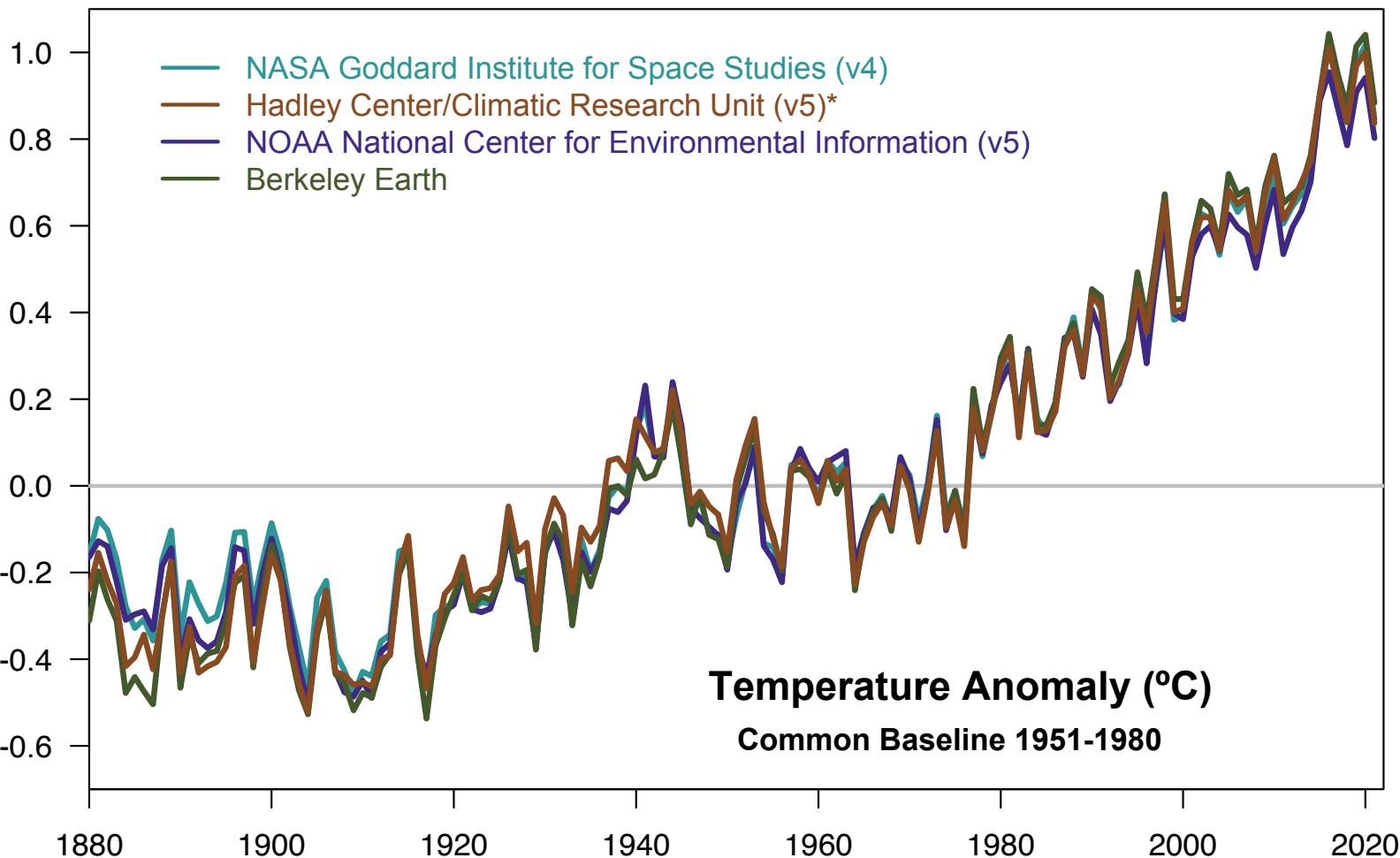
Differences from NOAA NCEI and HadCRUT5:

NOAA still not interpolating data sparse areas (particularly poles); Collation on equal area grid (~250km x 250km); Global and regional index estimation method; Different homogenization in HadCRUT. More similar now than in previous years.



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Comparisons with other indices

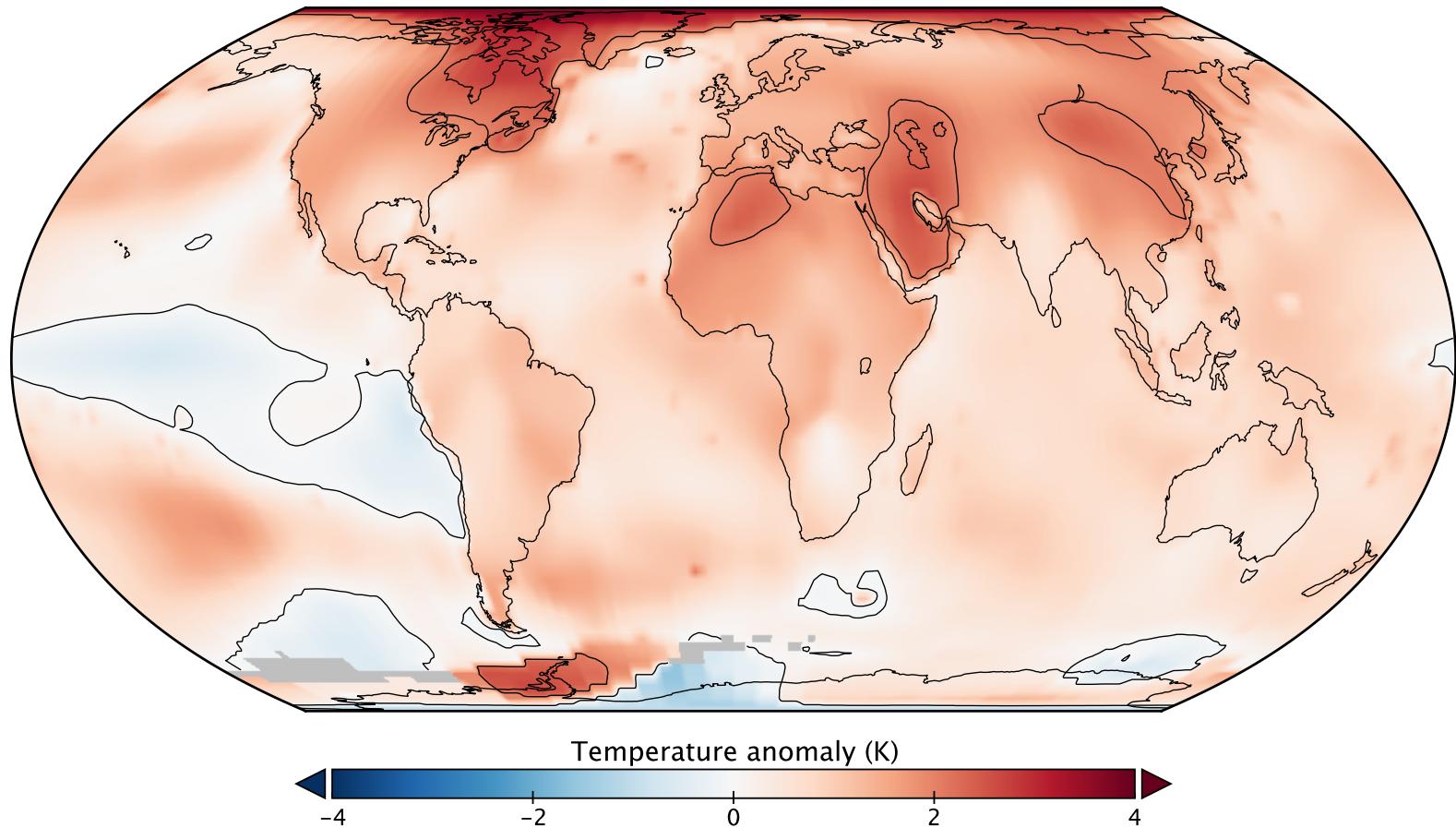




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2021 Anomaly Map

GISTEMP Annual Mean 2021
Baseline 1951–1980



Global: 0.85°C above 1951-1980 Baseline



Ongoing observational issues

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Systematic poor coverage in some parts of the world increases regional uncertainty

More sophisticated uncertainty quantification still needed

ERA5/AIRS/GISTEMP show some systematic differences

Better operational integration of Arctic buoy data and other satellite data sets needed

Data rescue efforts need to be better supported

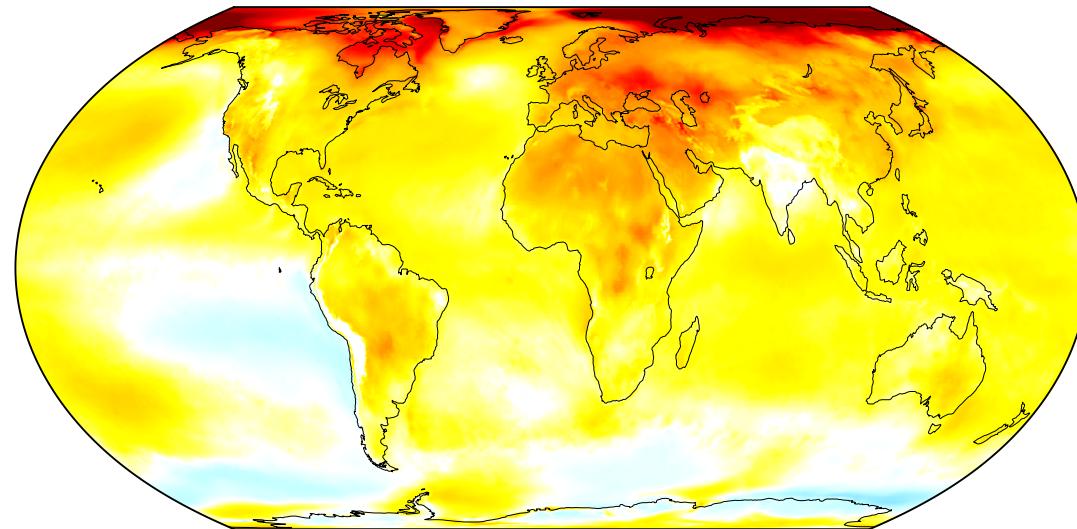


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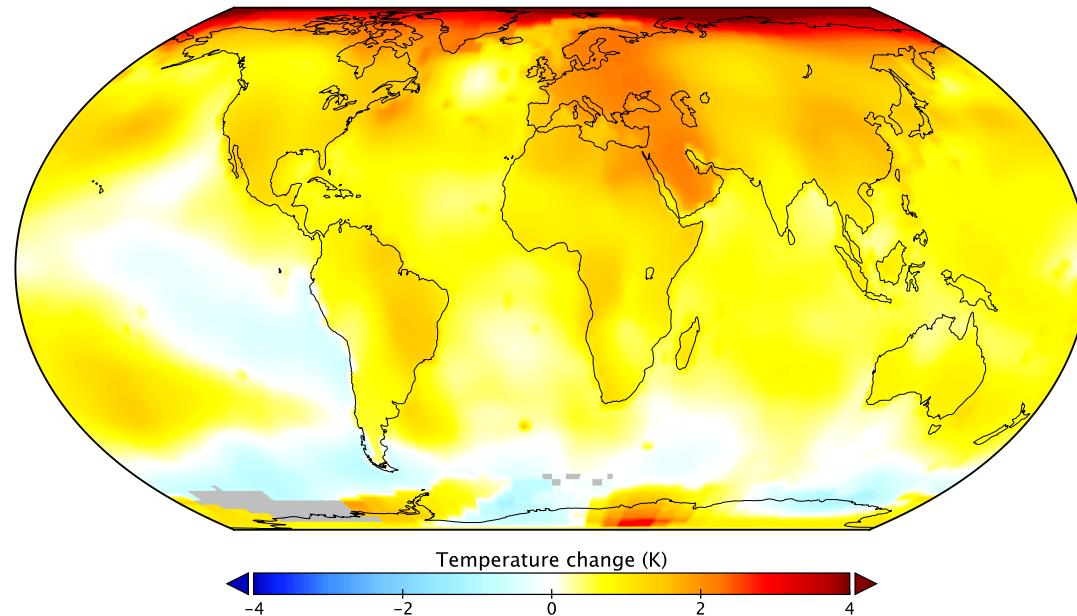
Comparison w/Reanalysis?

1979-2021 Trend

ERA5:
 $0.19 \pm 0.03^{\circ}\text{C}/\text{dec}$



GISTEMP:
 $0.19 \pm 0.02^{\circ}\text{C}/\text{dec}$

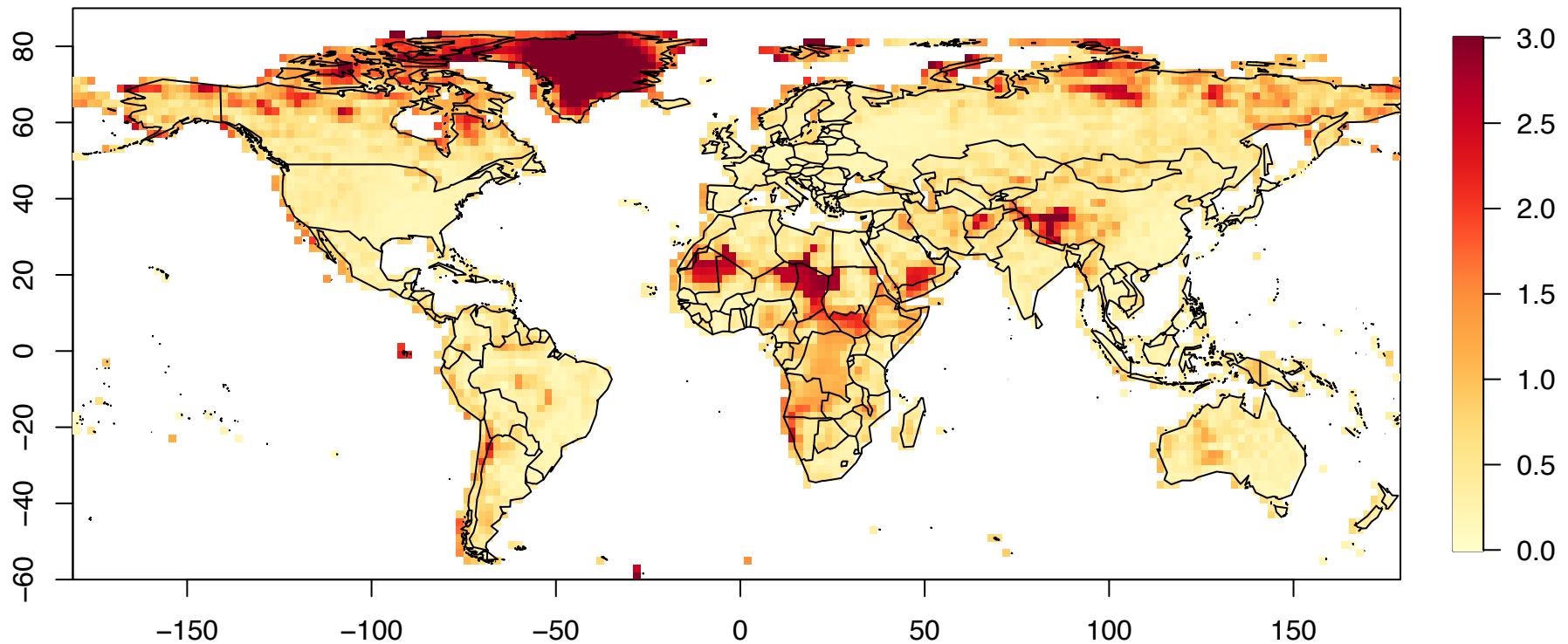




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Areas of difference line up with sampling uncertainty

Monthly Sampling Uncertainty 95% Confidence Interval (Jan 2016)



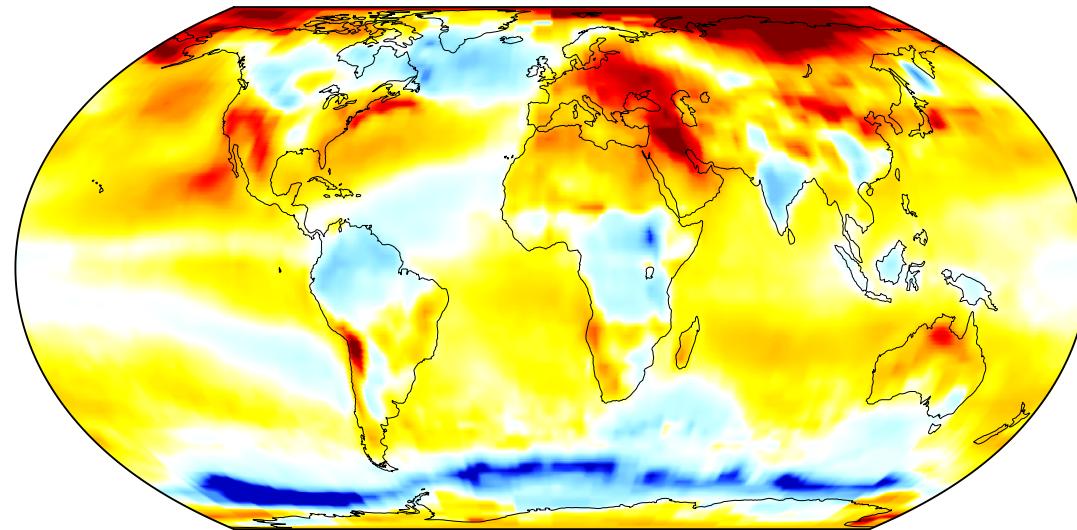


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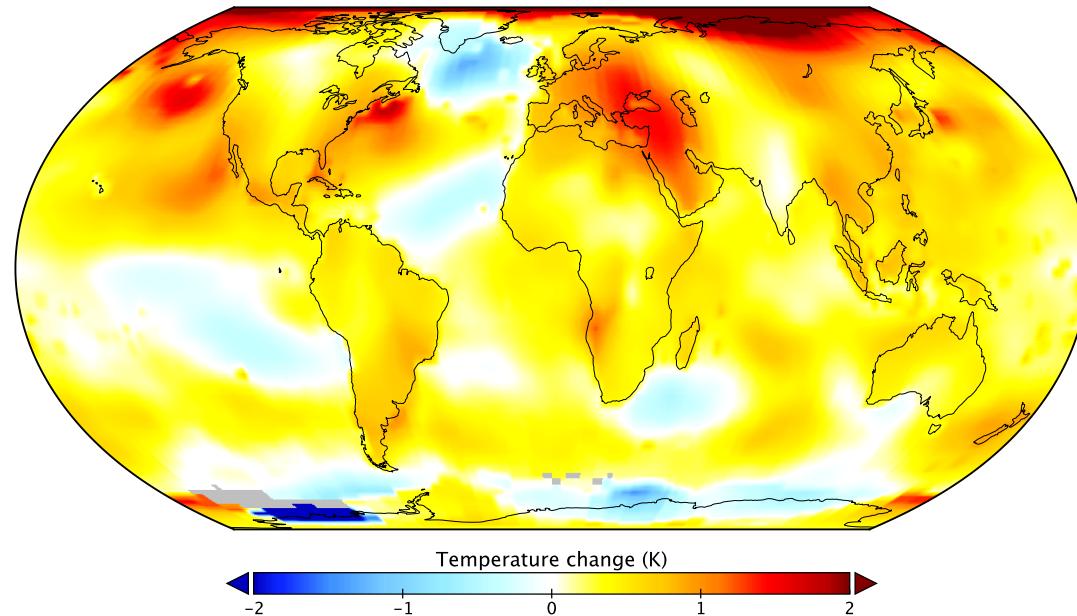
Comparison w/Remote Sensing?

2003-2021 Trend

AIRSV7:
 $0.16 \pm 0.1^{\circ}\text{C}/\text{dec}$
(AIRSV6:
 $0.23 \pm 0.08^{\circ}\text{C}/\text{dec}$)



GISTEMP:
 $0.23 \pm 0.08^{\circ}\text{C}/\text{dec}$



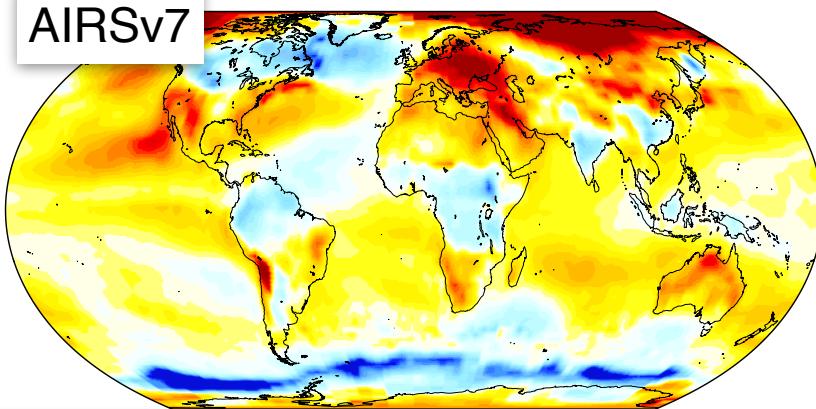


Satellite retrieval versions differ

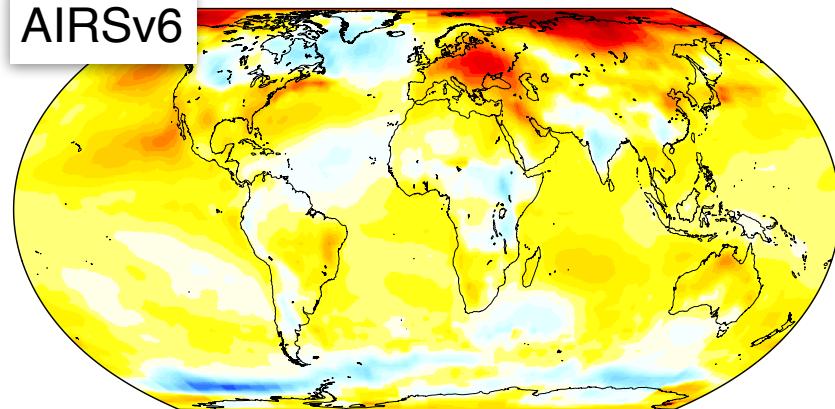
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2003-2021 Trend

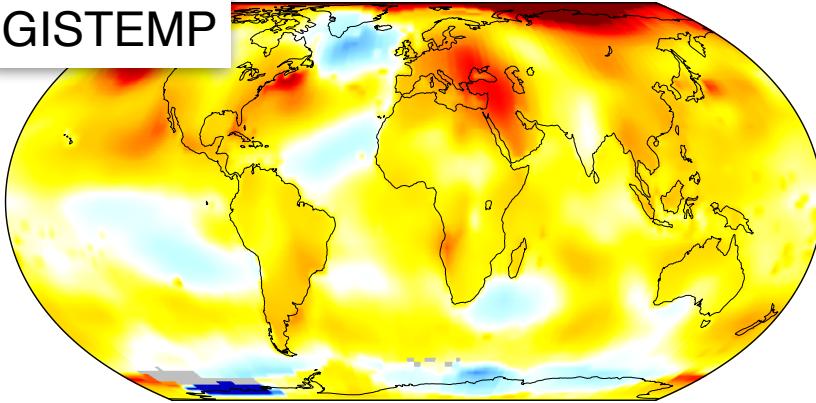
AIRSV7



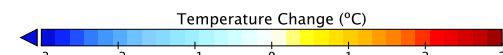
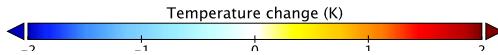
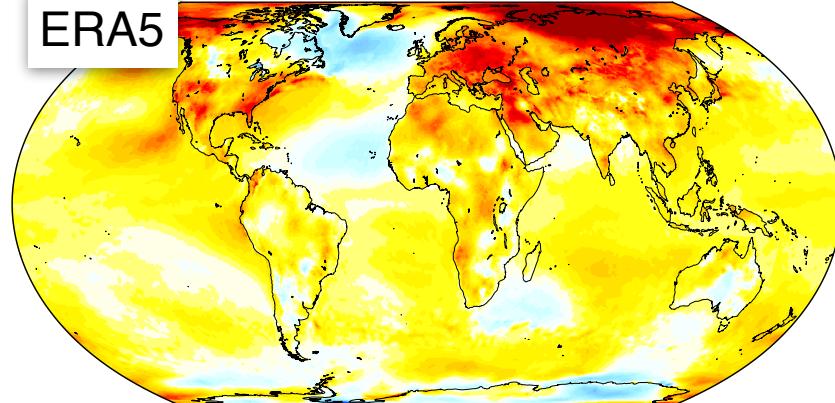
AIRSV6



GISTEMP



ERA5

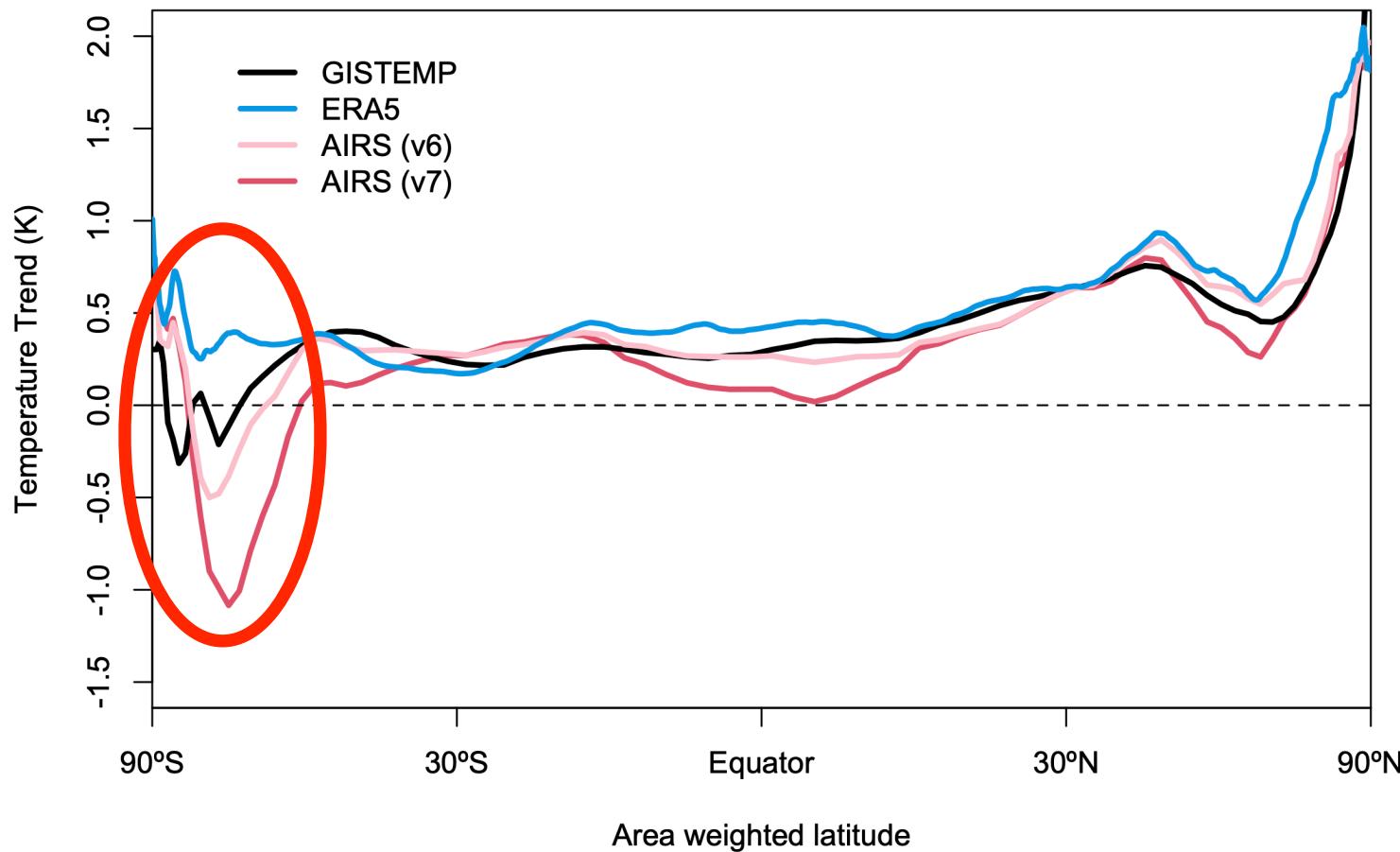




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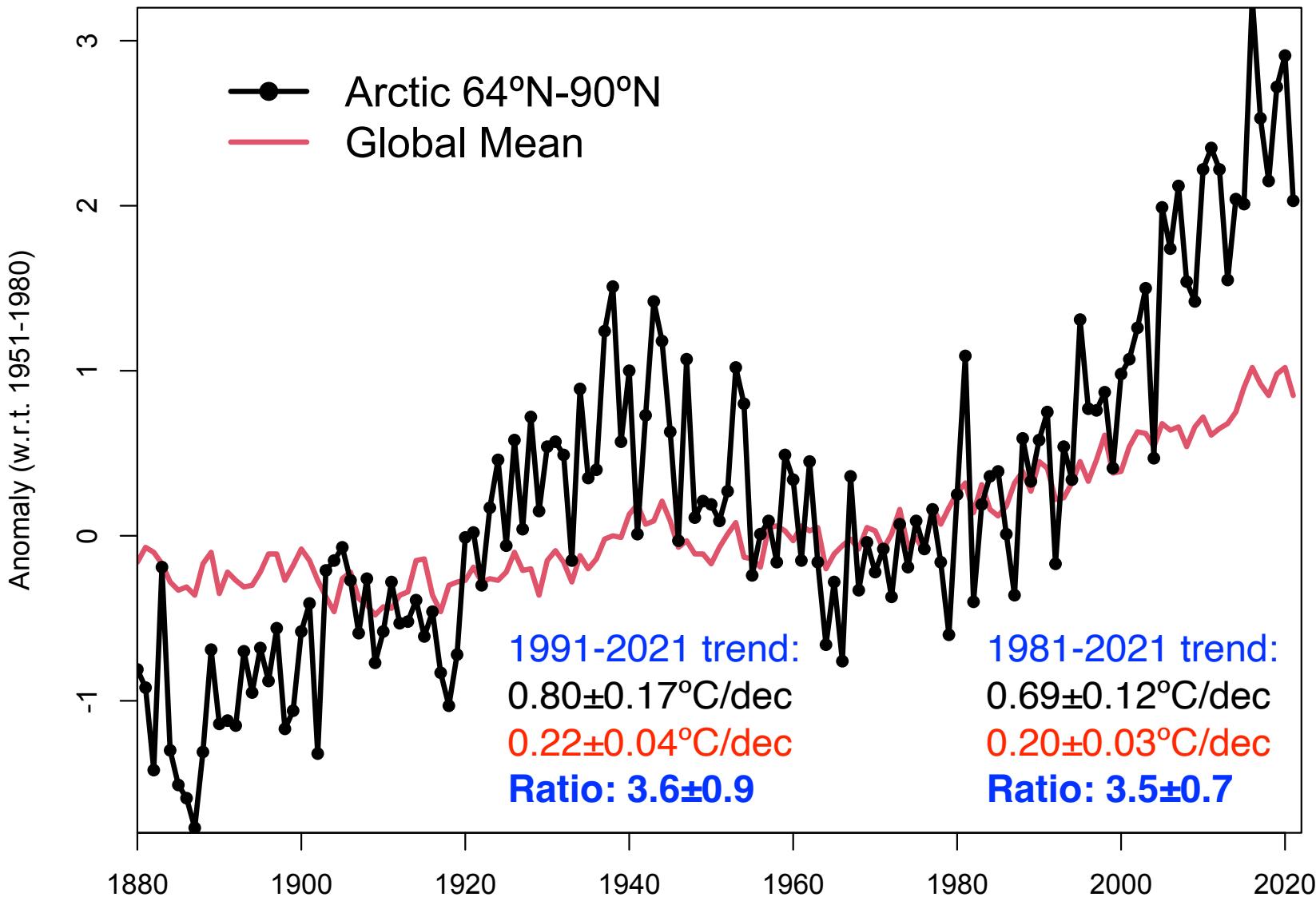
Southern Ocean trend differences are large and potentially important

Zonal Mean Trends (2003-2020)





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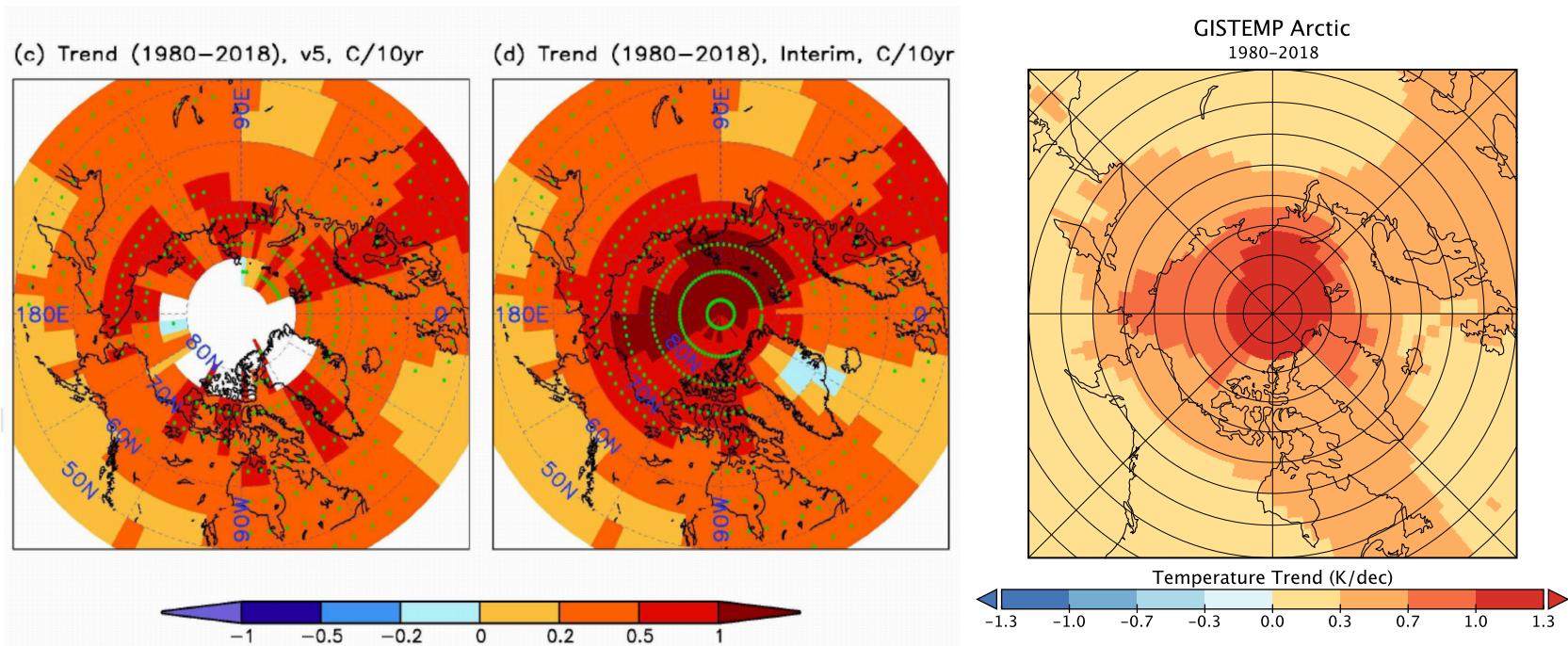


'Filling' the Arctic hole

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Unlike GISTEMP, HadCRUT4 and NOAAGlobalTemp v5 do not interpolate in data-poor Arctic regions.

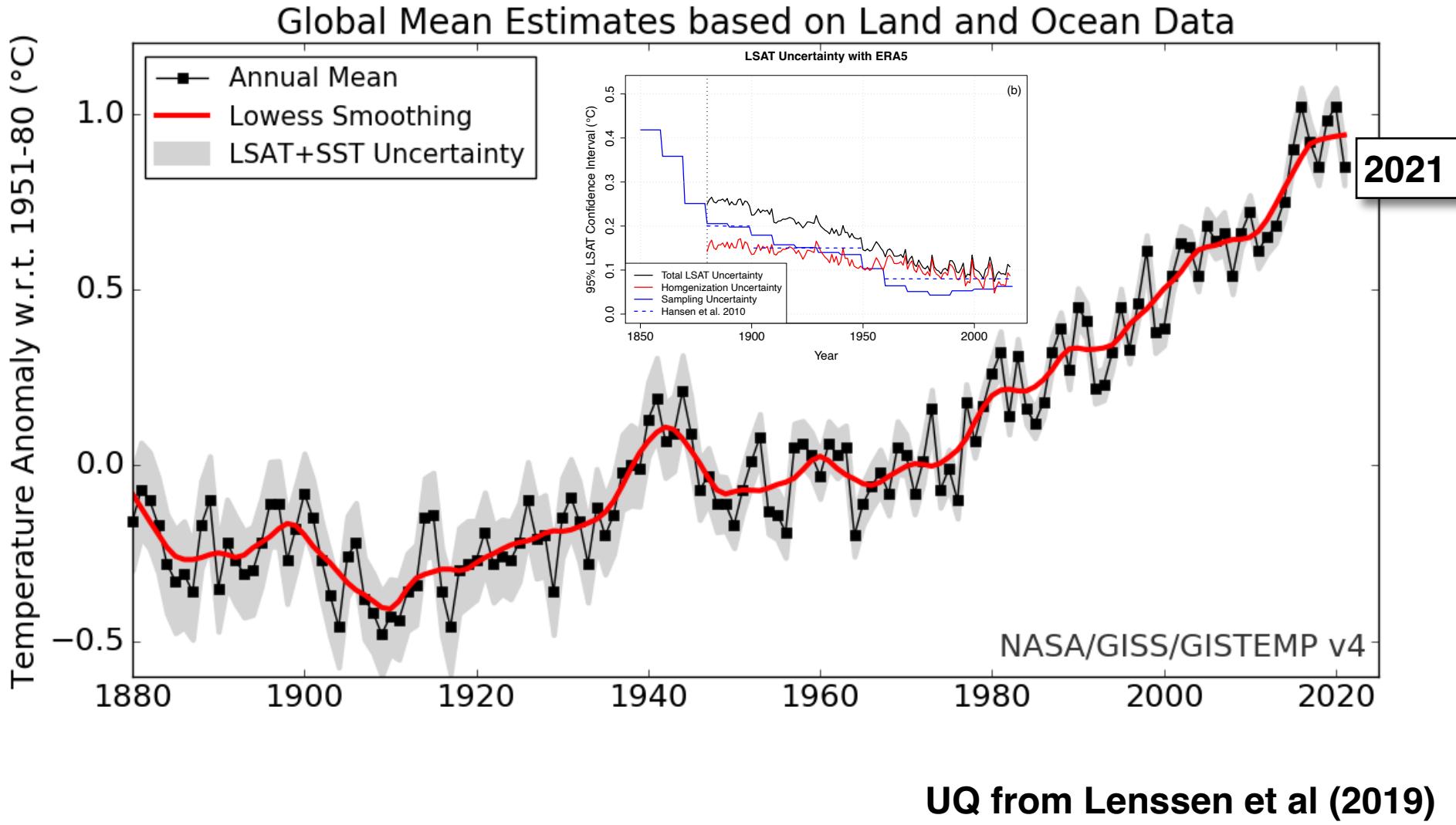
Recent updates (HadCRUT5 and NOAAGlobalTemp (Interim)) fix this
NOAAGlobalTemp is uniquely using Arctic Buoy Program data.





Uncertainty quantification still needs work

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Ensemble approach

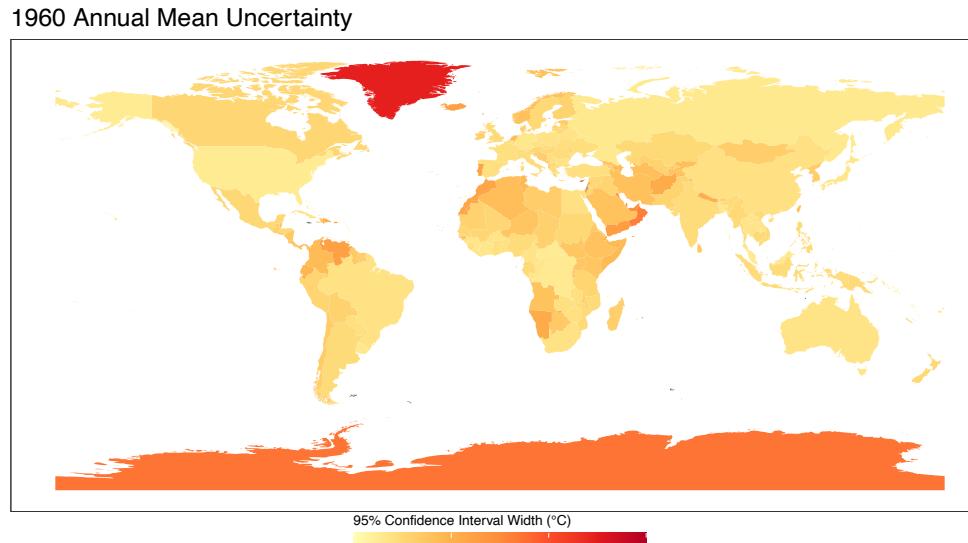
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Use ensembles from ERSSTv5 and GHCNv4

Generate ensembles of GISTEMP analysis

Combine to get full ensemble, covering
observational, sampling, homogenization and
structural uncertainty

Better spatio-temporal representation than current
approach





2021 Summary

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Convergence on global mean trends across products

Regional uncertainties persist

Improvements in UQ/processing will help

Independent remote sensing of SAT is very useful

Note AIRS (since 2003) will likely cease operation in
a couple of years

Reanalyses (especially ERA5) now comparable w/in
situ estimates (from 1979)

Inclusion of Arctic Buoy program data promising
(NOAA Interim)